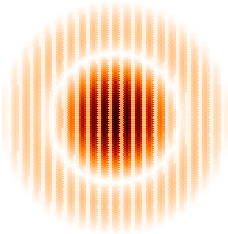


# Aperture Masking at Keck


Peter Tuthill

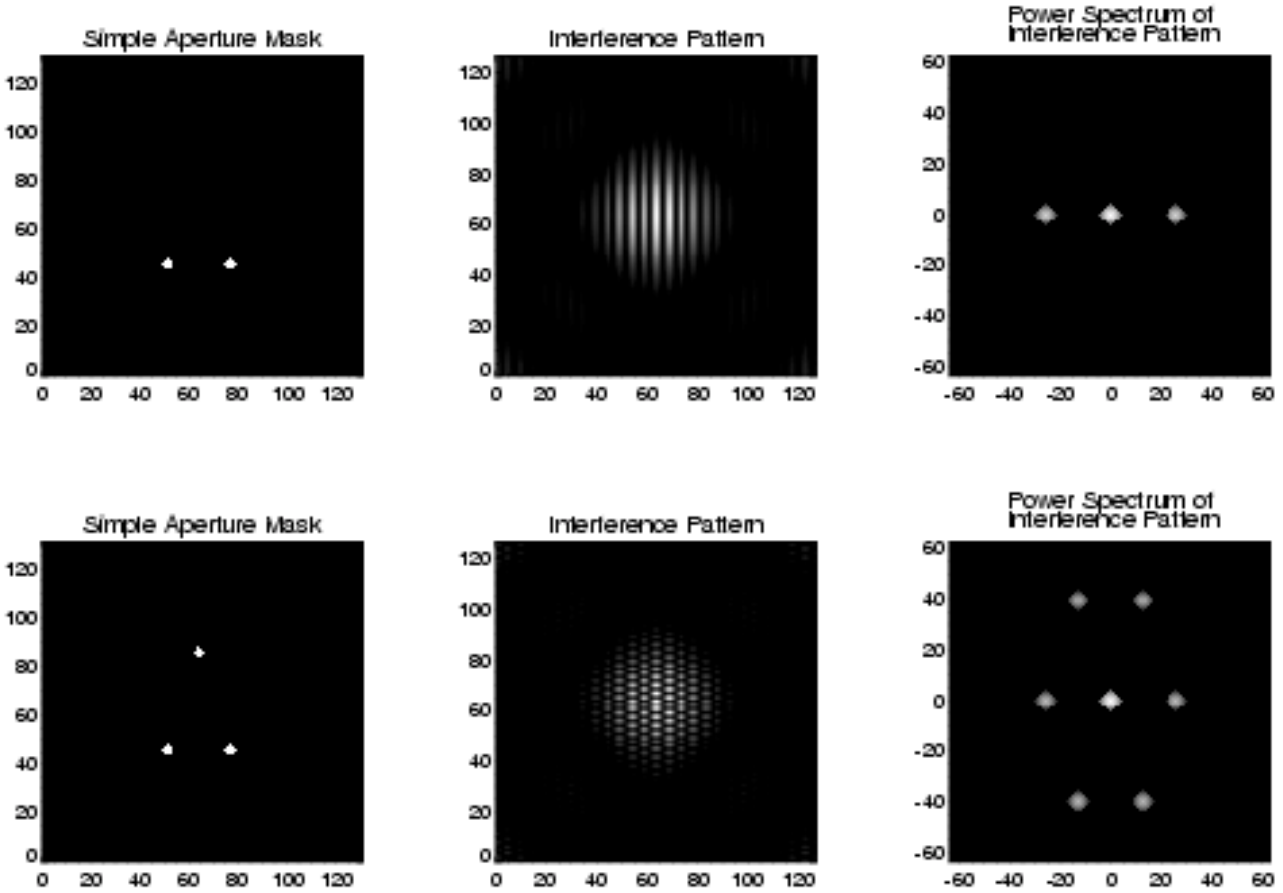
Sydney University


Collaborators

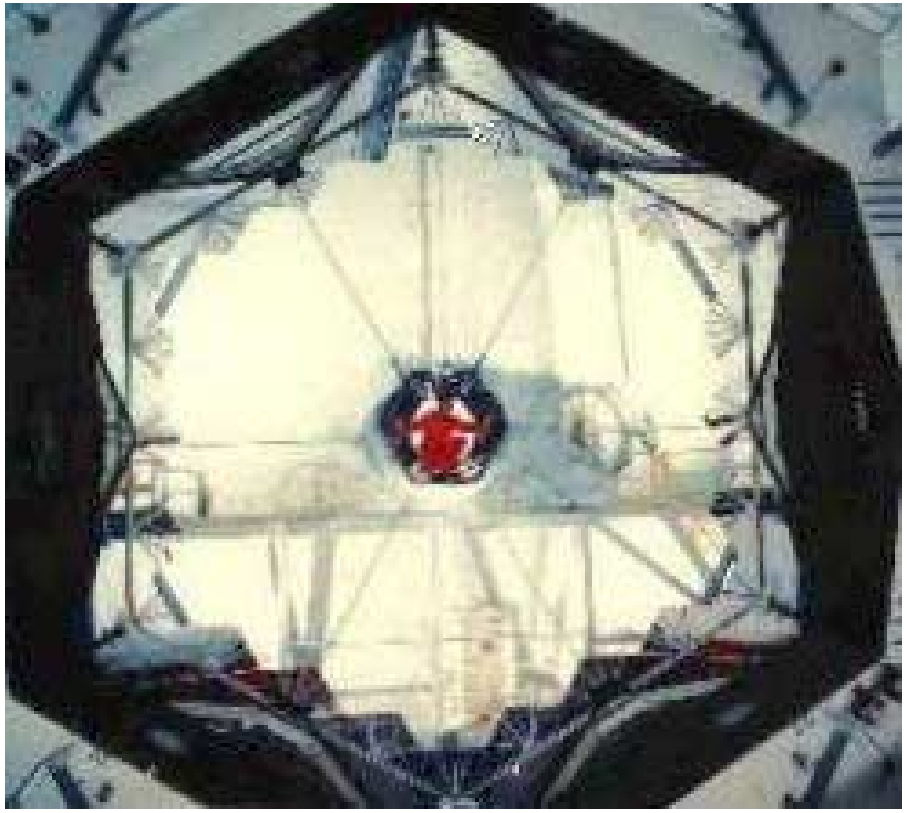
John Monnier (CFA)

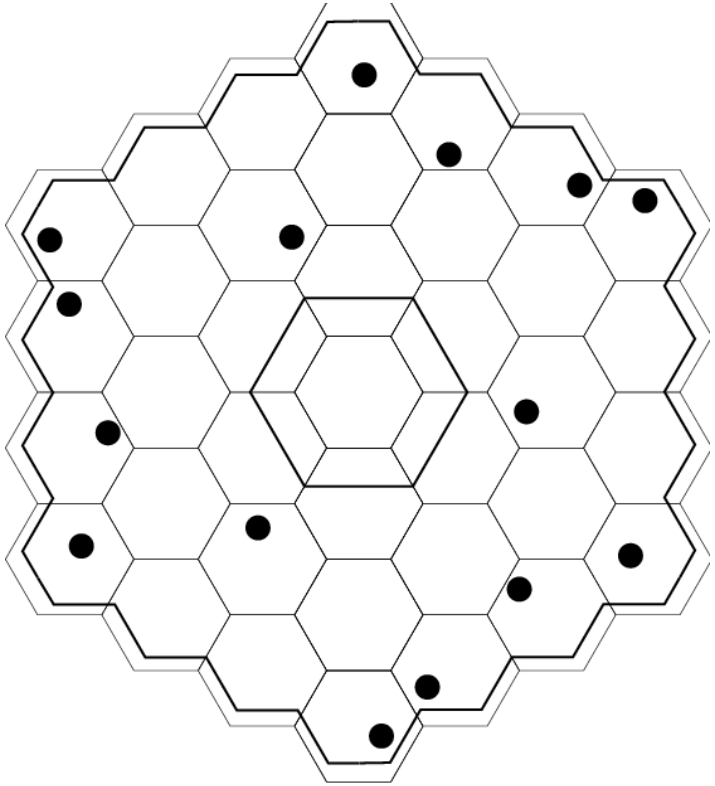
Bill Danchi (NASA-GSFC)

# Aperture Masking: Examples

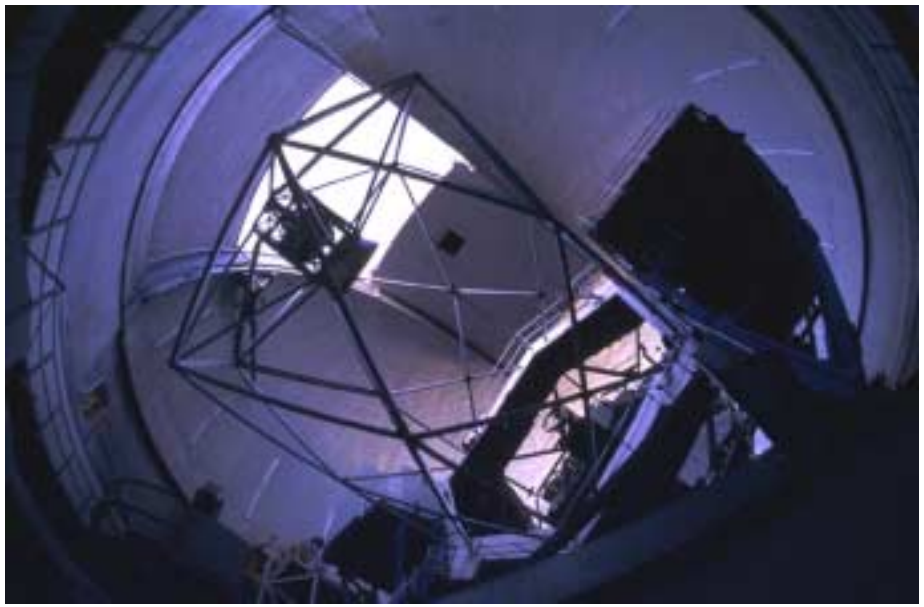


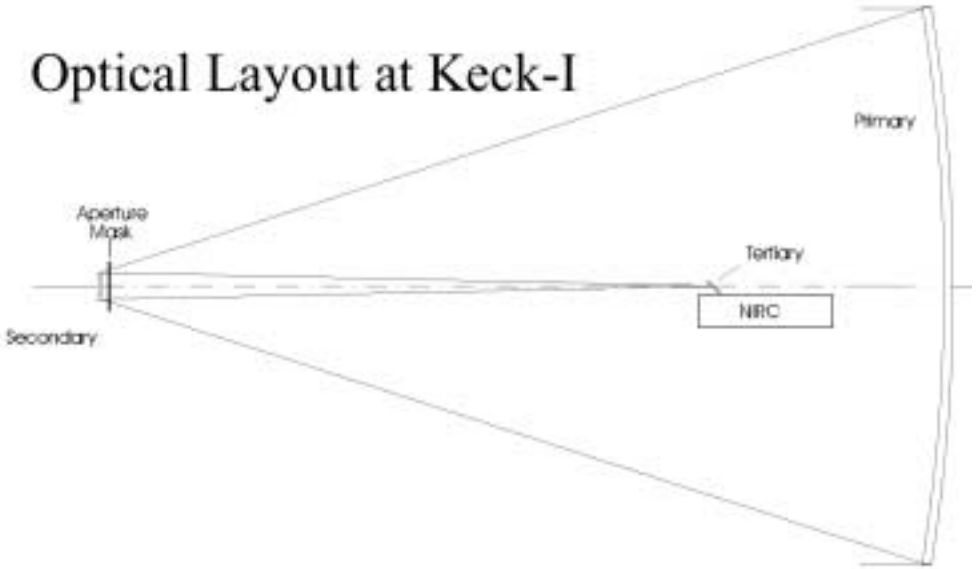
# Keck-I Telescope: 10-m Segmented Primary



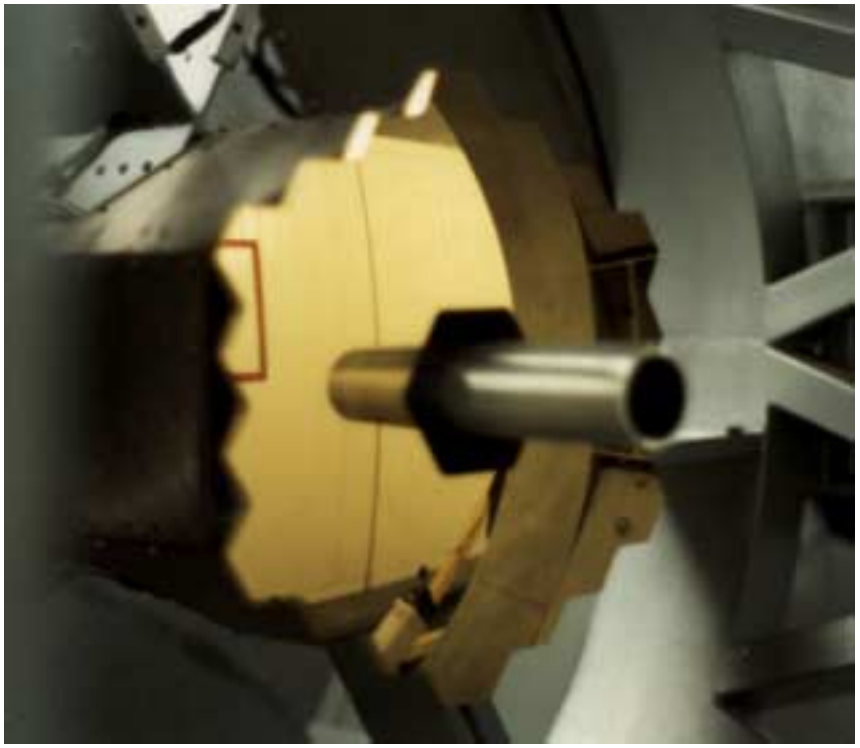


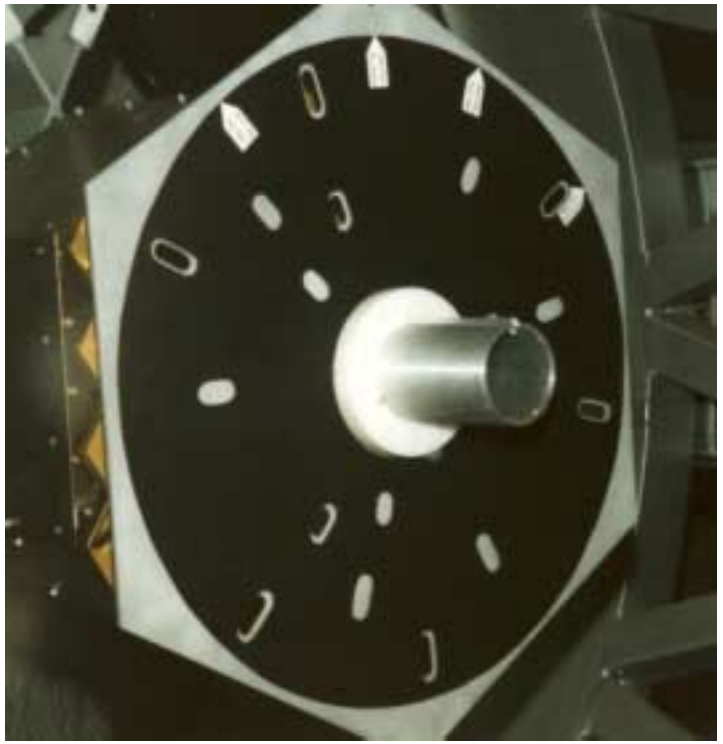
# Installing the Aperture Mask





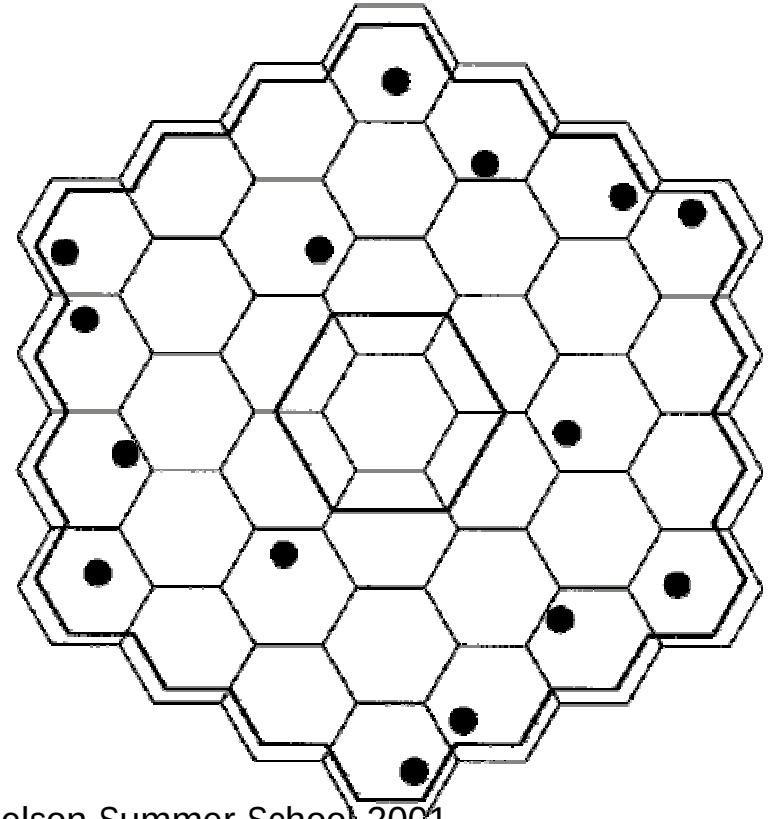
# The Secondary Mirror & Mask



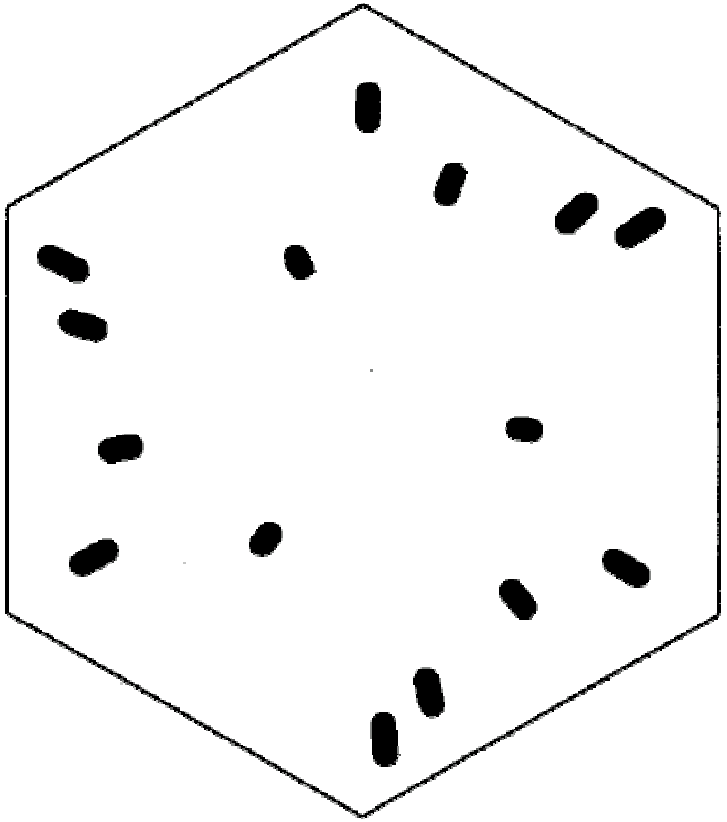


# Non-Redundant 15-Hole Aperture Mask

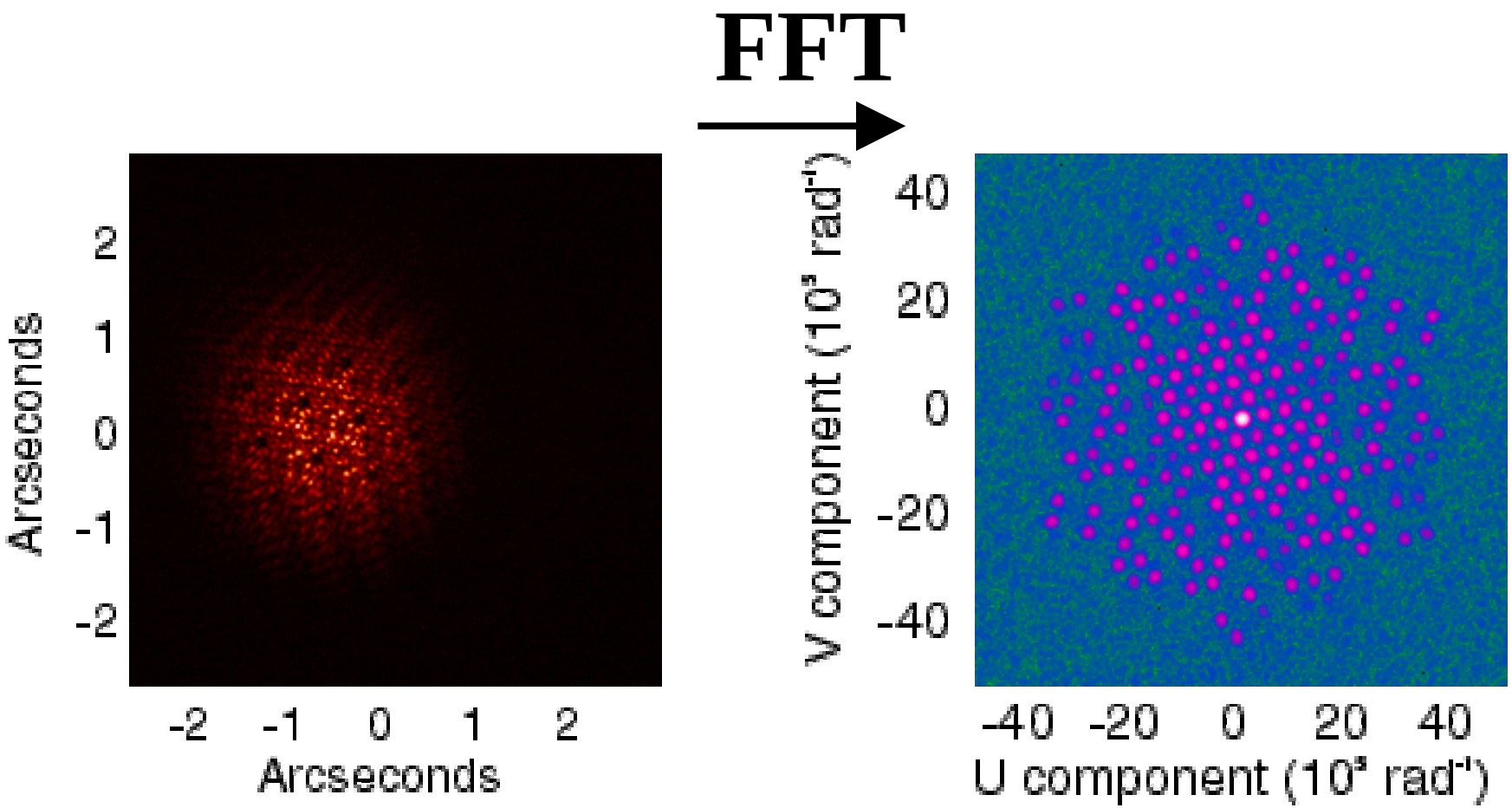
As Projected onto Primary Mirror



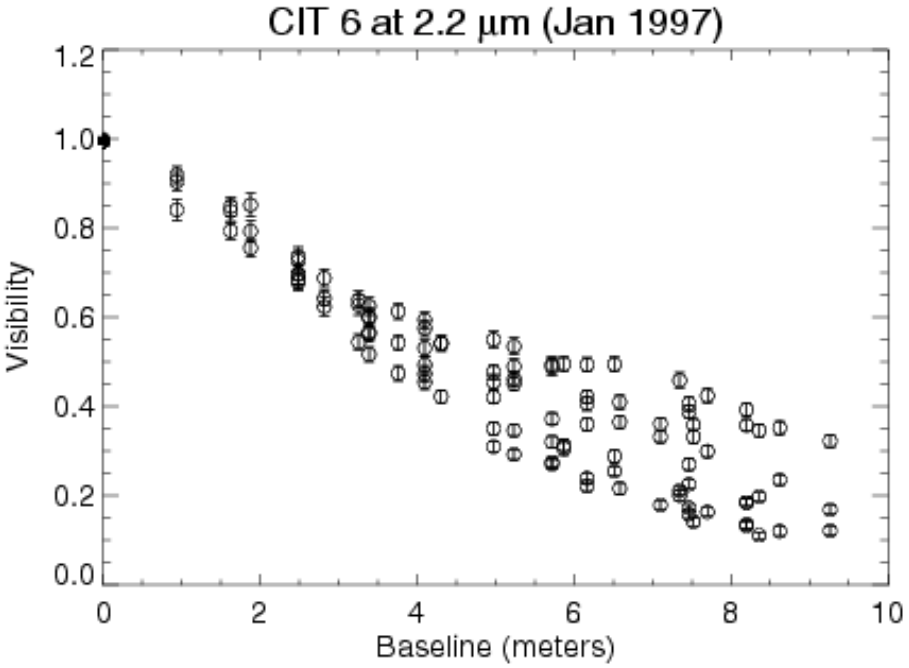
As Cut into the Aluminum Mask

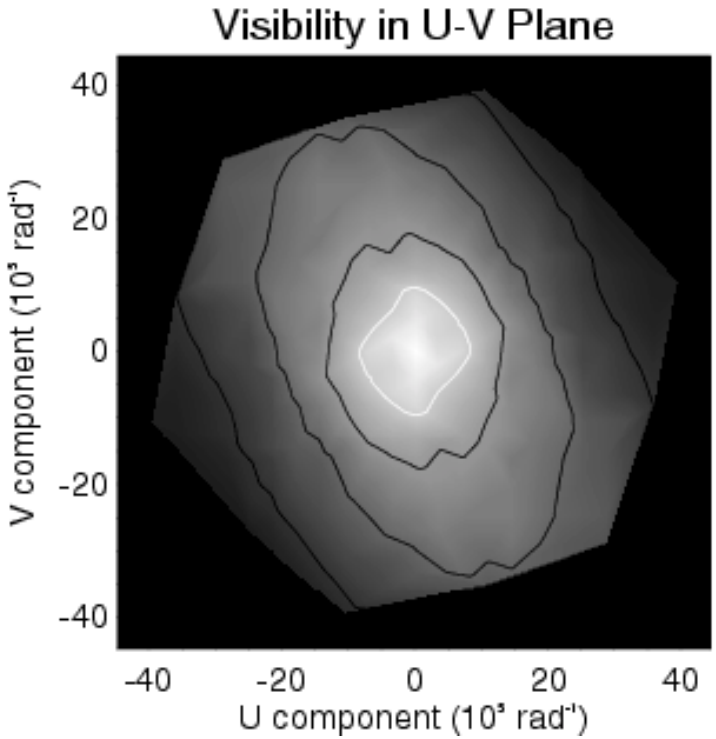


# Speckles and Power Spectra



# Analyzing The Amplitudes...

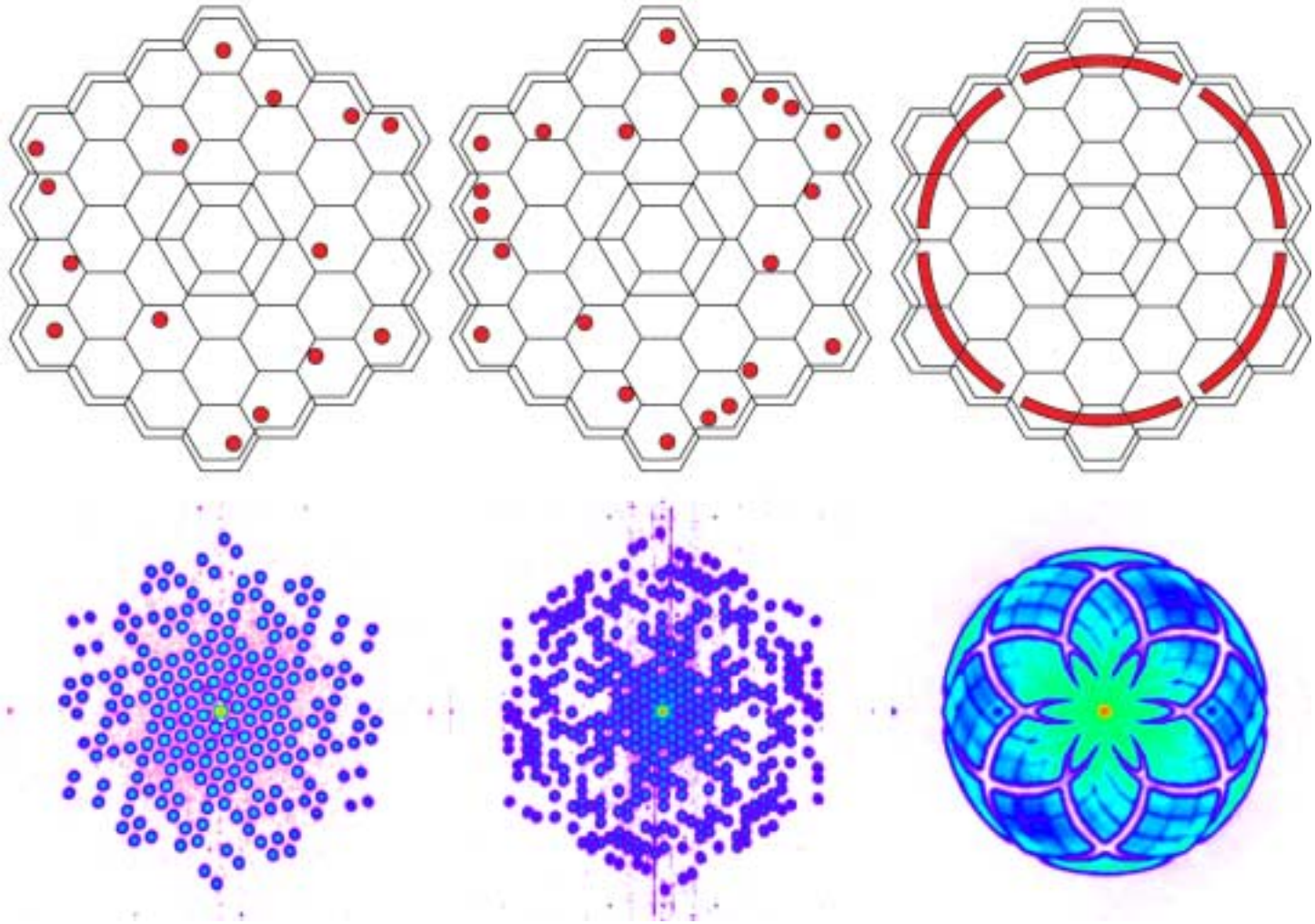


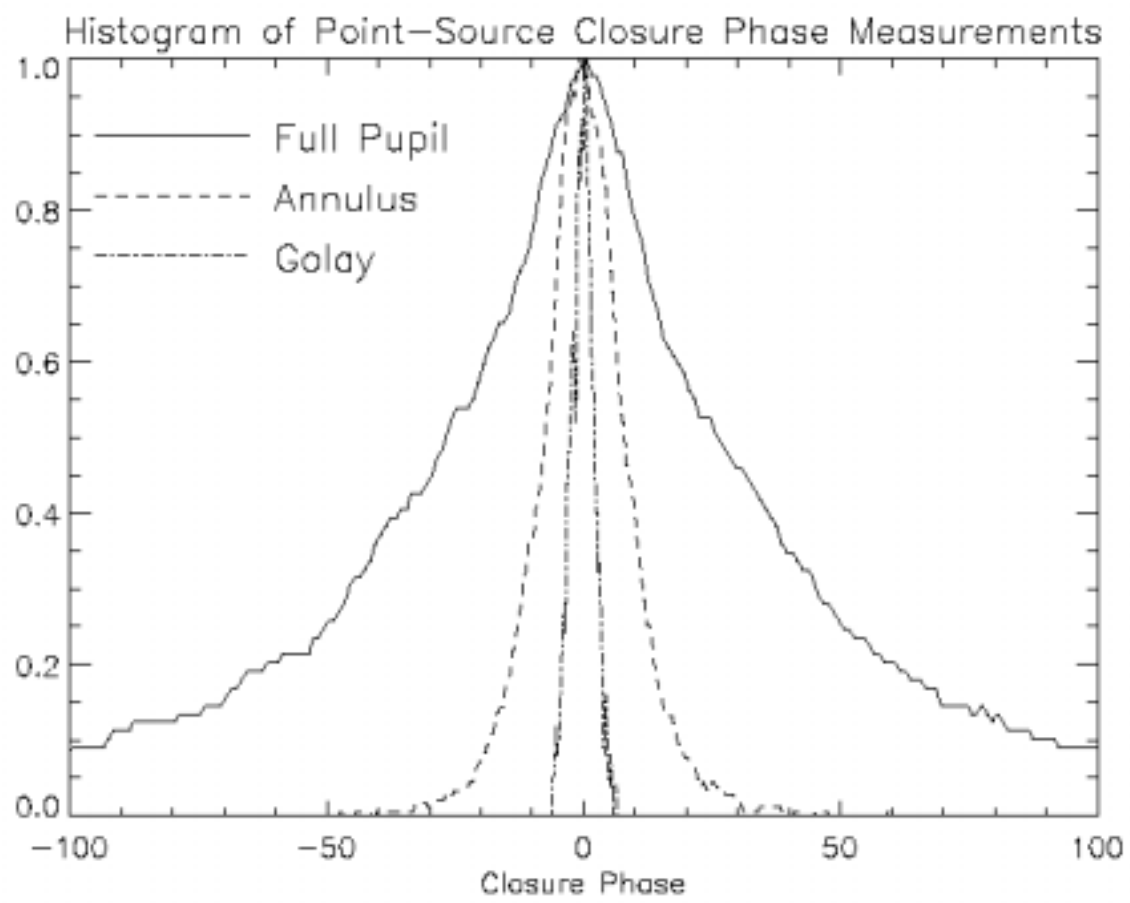
# Observing Details

- NIRC camera
  - Helium cooled InSb array
  - Interference filters 1 to 3.5 microns (typical 1-5% bandwidth)
  - Integration time 140 millisec
  - Nyquist sampled at 2 microns (aliased at J and H)
  - Data cubes of 256*256*100 frames
  - Read noise of 60 electrons
  - High Resolution Mode: Lyot stop not functional
- Observing Strategy
  - Keck time $1.00 per second
  - Source – Calibrator typical delay 5-10 minutes
  - Good calibrators hard to find – multiply used and sometimes far away
  - Attempt to get parallactic angle change for asymmetric sources
  - Typically 4-6 mask changes per night (10-minute operation)
  - Multiple wavelengths taken on each source
  - Keep transfer function constant

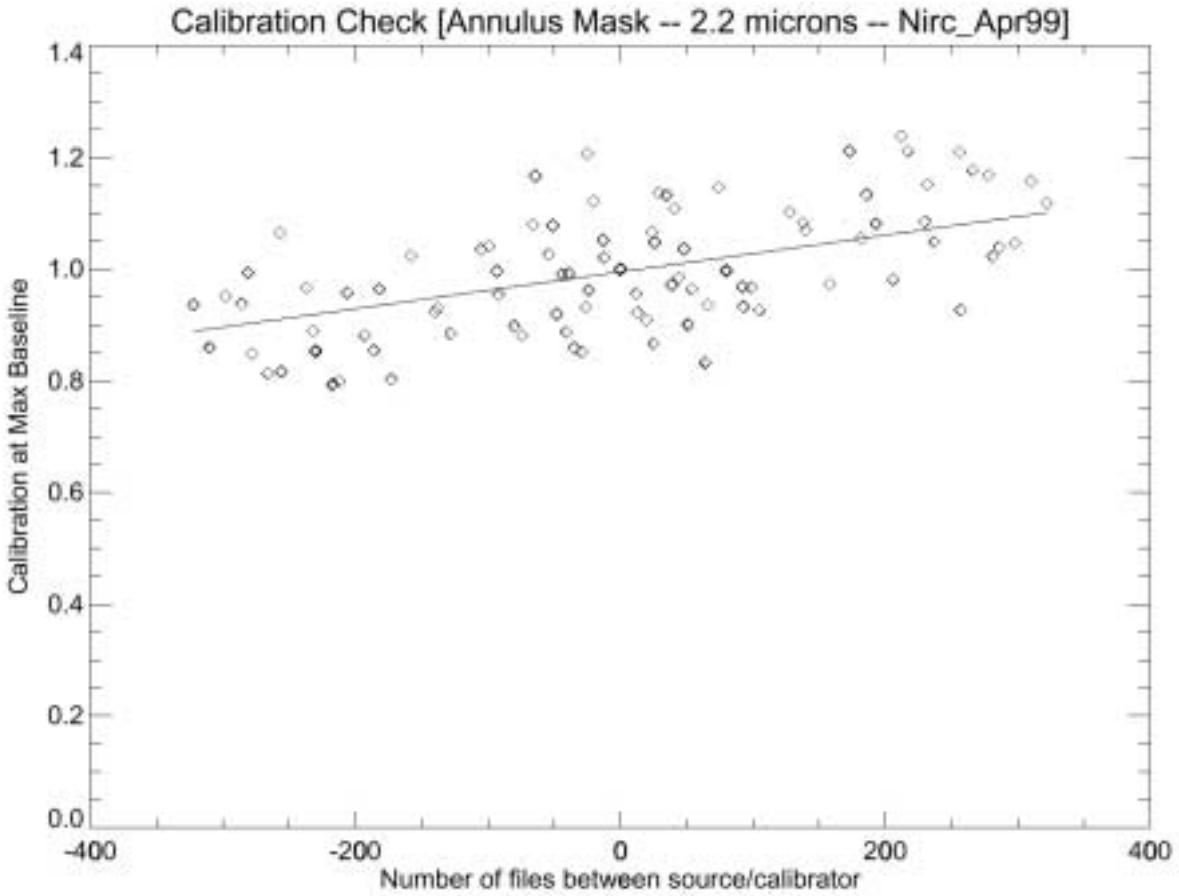
# Other Aperture Masks



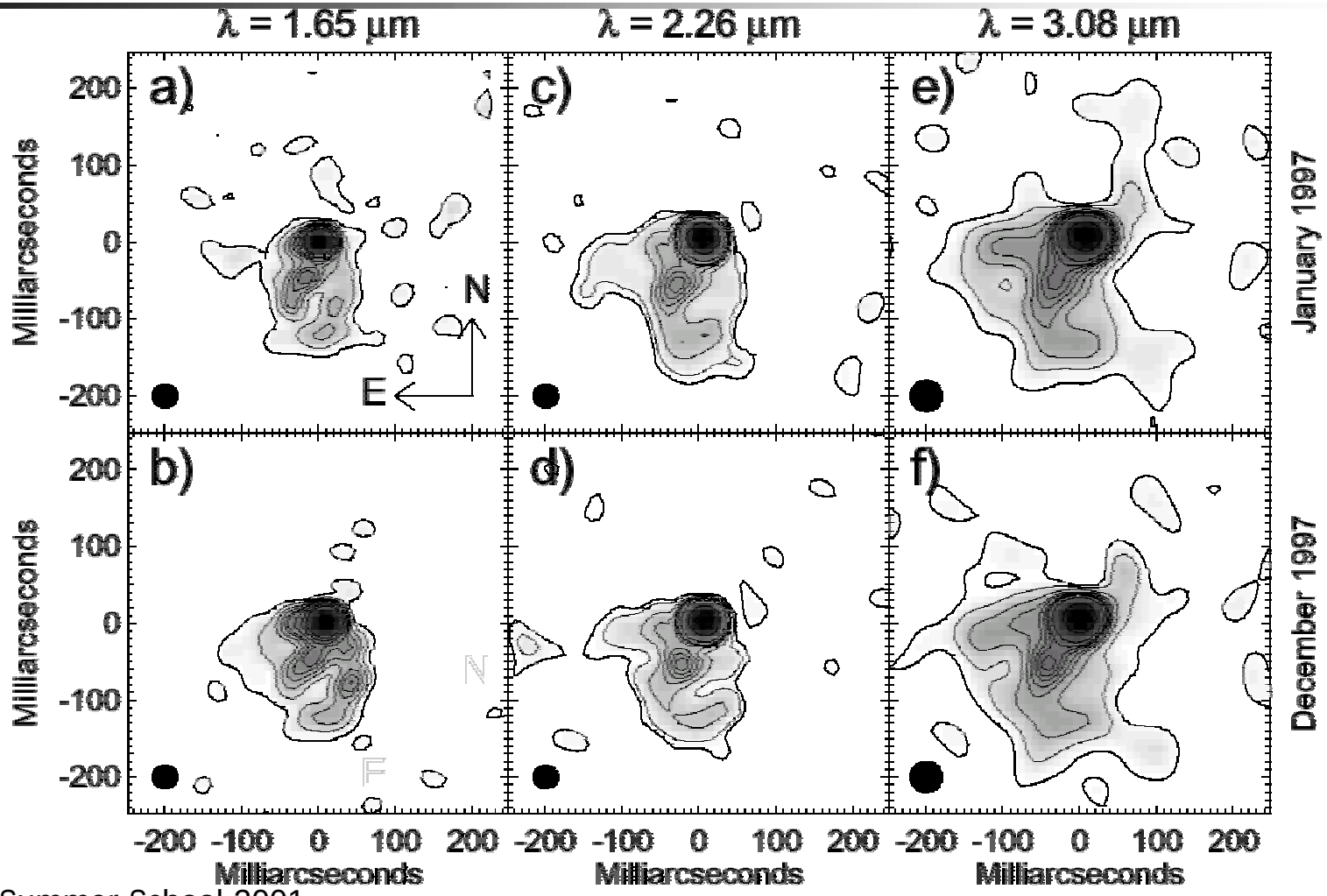
# Closure Phase Comparisons



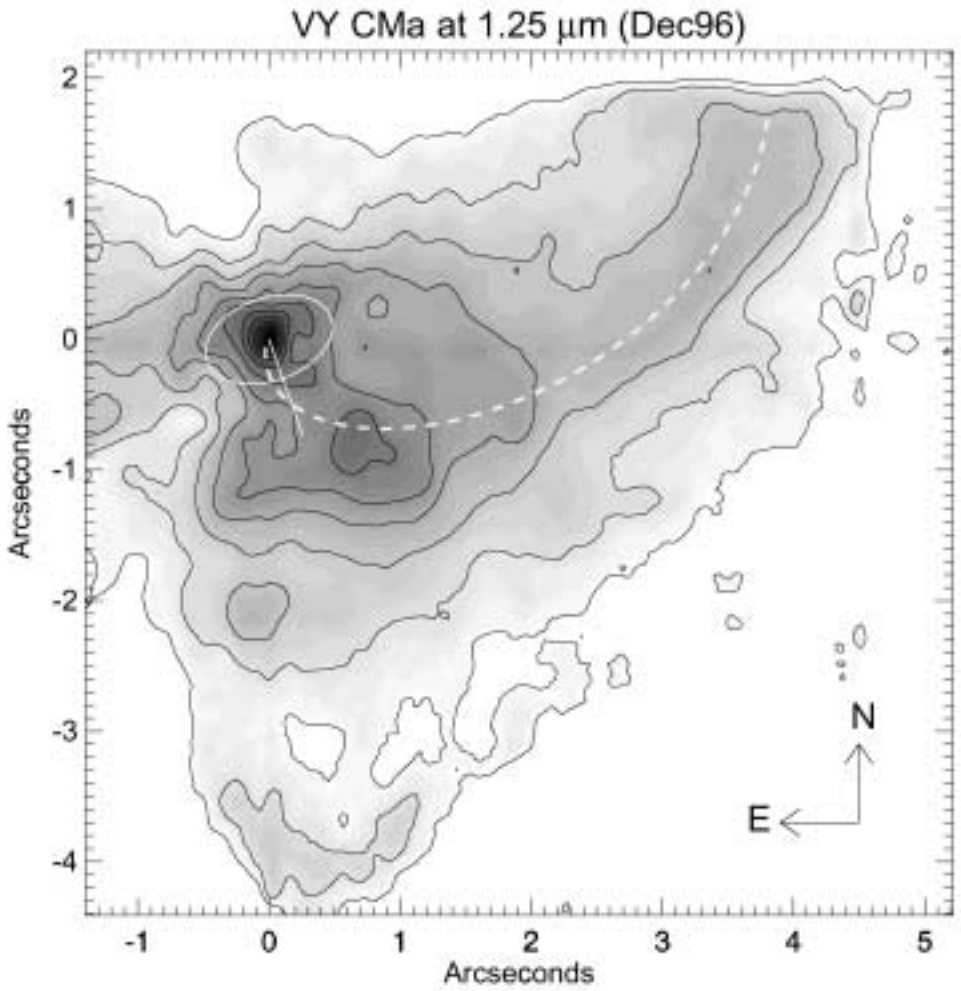
# Calibrating the Visibility

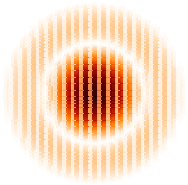


# VY CMa in the Near-IR



# Adaptive Optics Imagery

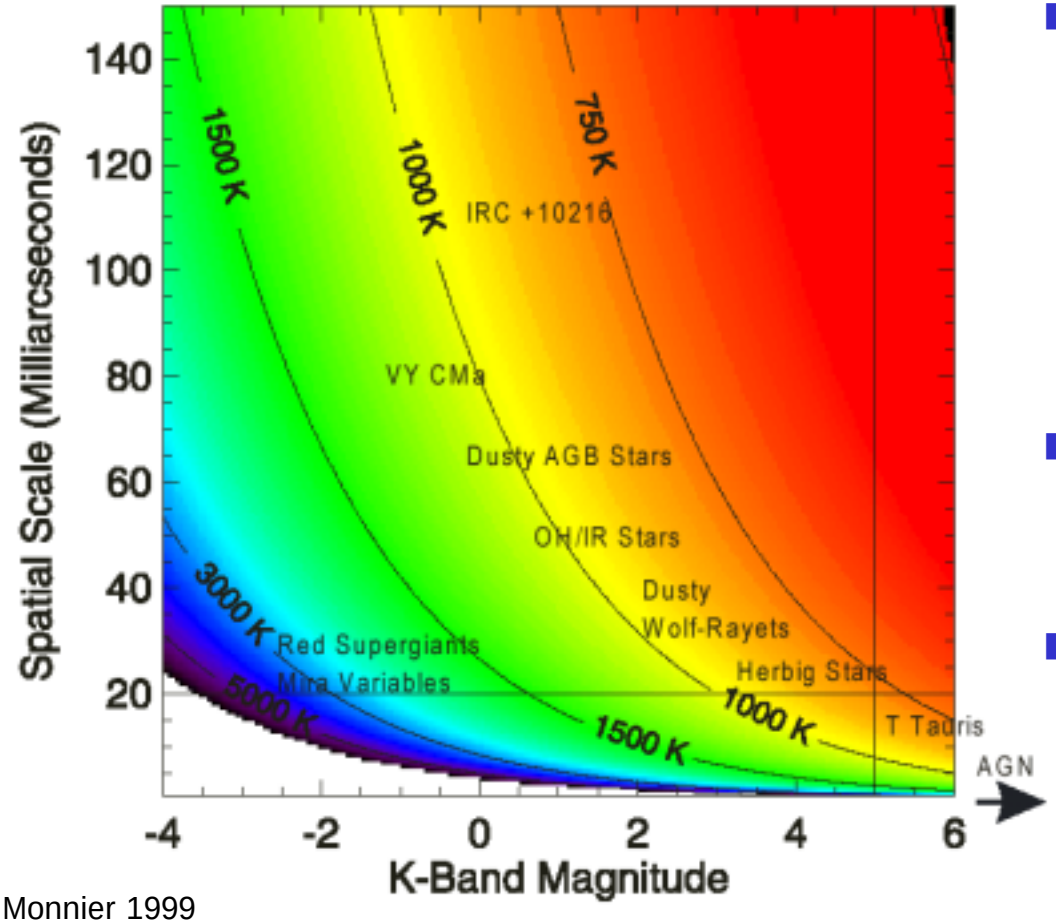




# Comparison to Other Techniques

- Aperture masking
  - Calibration is insensitive to seeing variations
  - Superior signal-to-noise ratio for bright sources
  - Utilizes existing imaging codes developed for radio
  - Less Photons - Avoids NIRC saturation (Betelgeuse K mag –4)
  - Very limited UV coverage and Field Of View
- Speckle Imaging
  - Full UV coverage
  - More Photons!
  - Lower SNR on each datum
- Adaptive Optics
  - Calibration of sky AND AO system more difficult
  - Require bright optical counterpart
  - Relatively Large FOV but imperfectly corrected

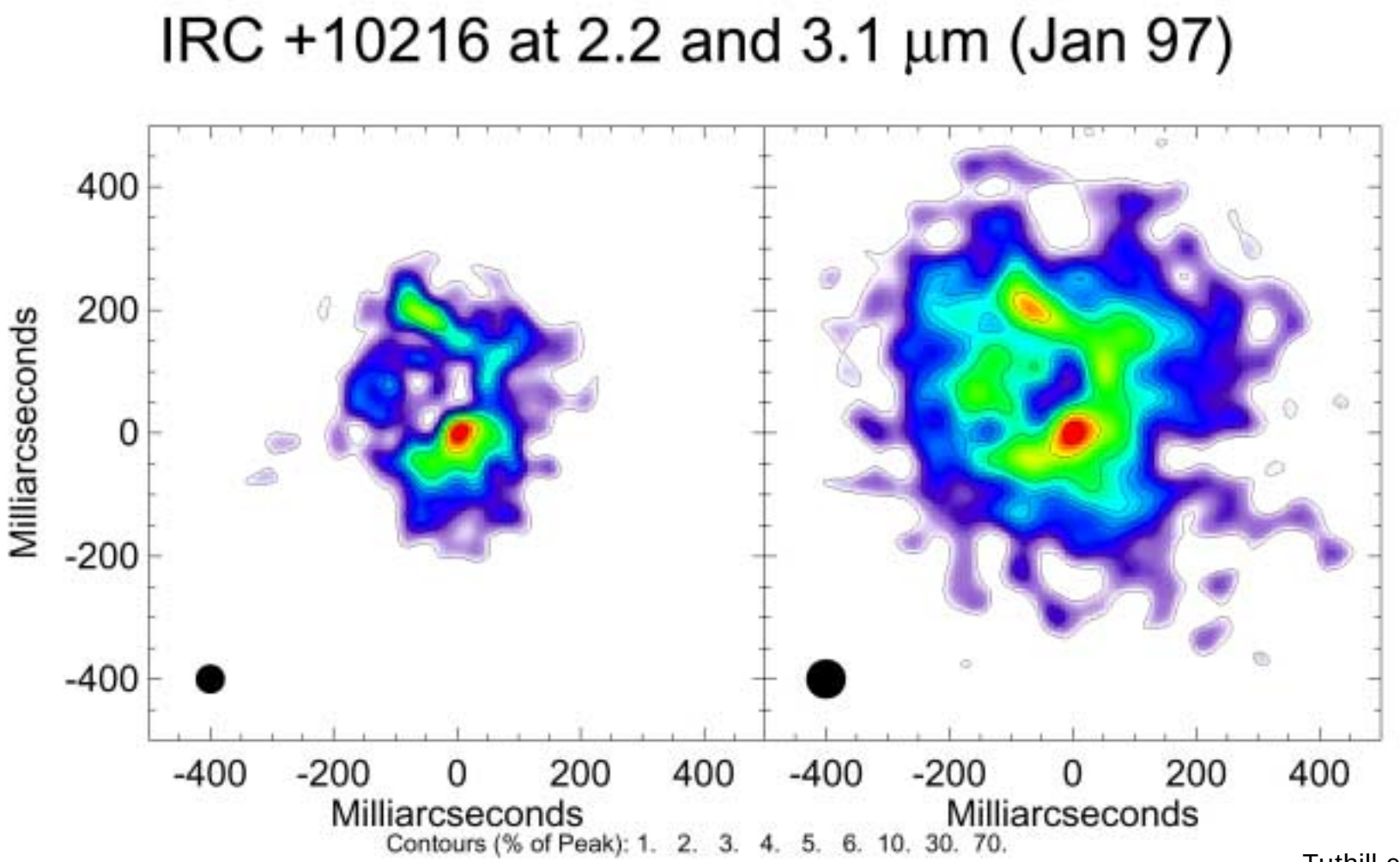
# Parameter Space




Monnier 1999

- Evolved Stars
  - Photospheres
    Hotspots and opacity effects
  - Mass-loss and dust formation
- Wolf-Rayet stars
  - Colliding winds
- Young stellar objects
  - What is the size of IR emission?

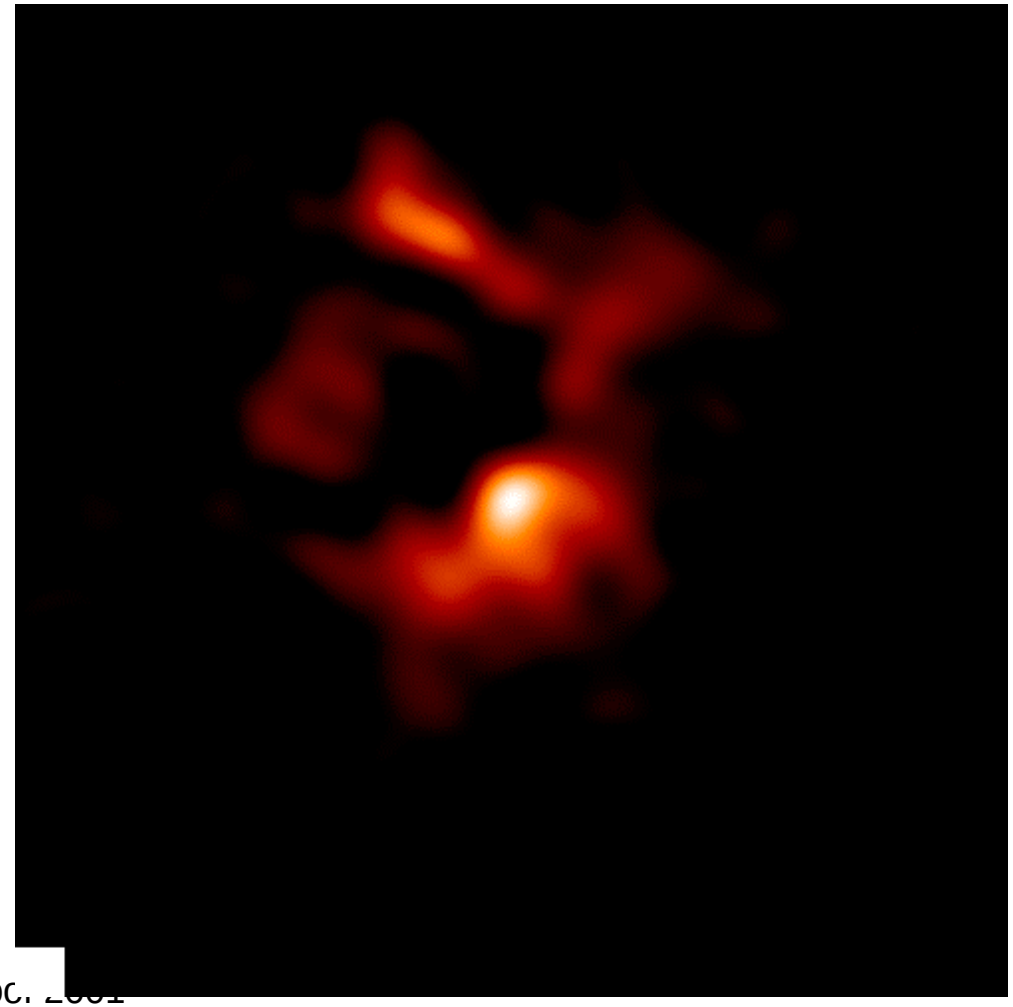
# Clumpy Dust Formation




Miche

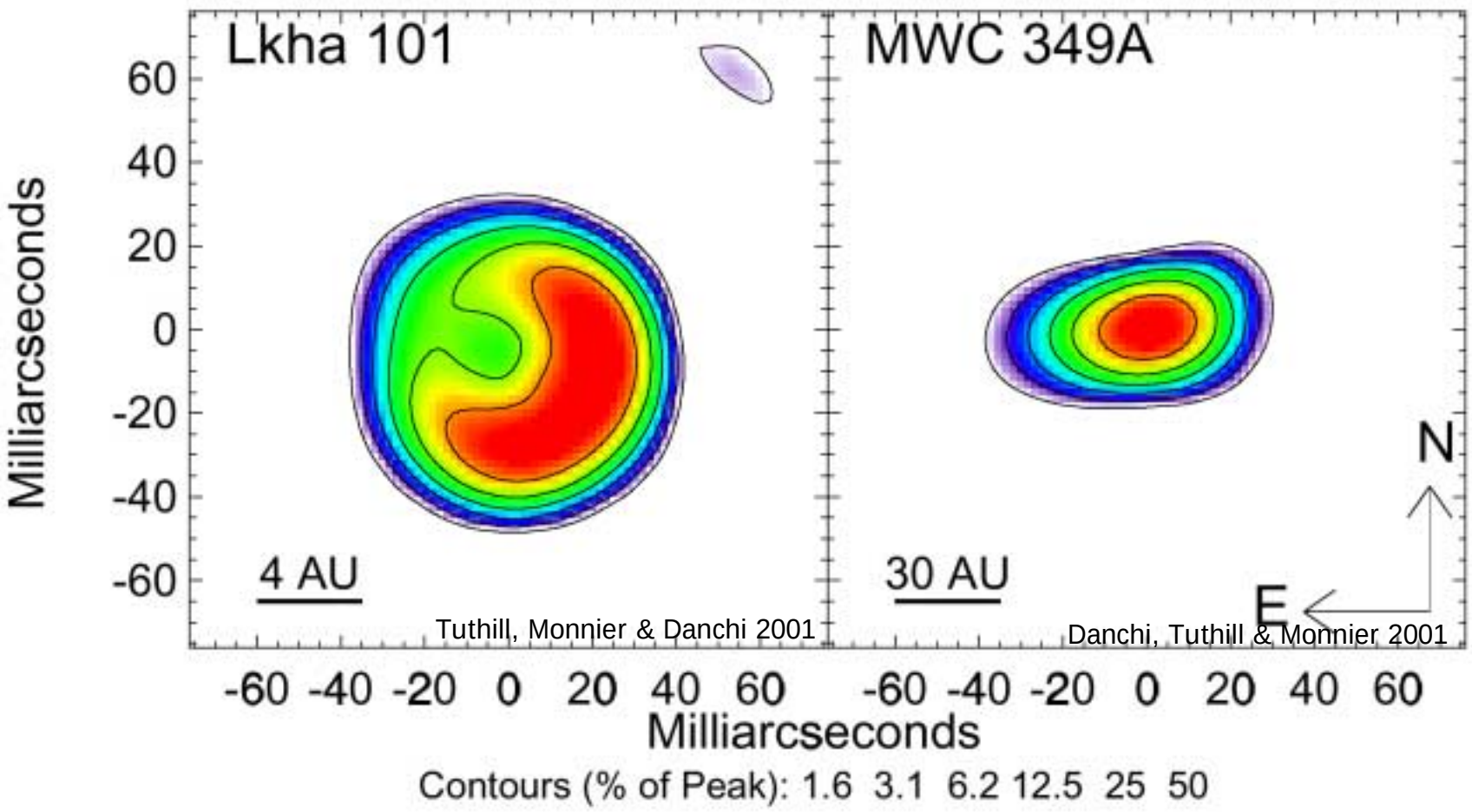
Tuthill et al 2000

# IRC +10216 Movie (3.5 years)



**20 AU**

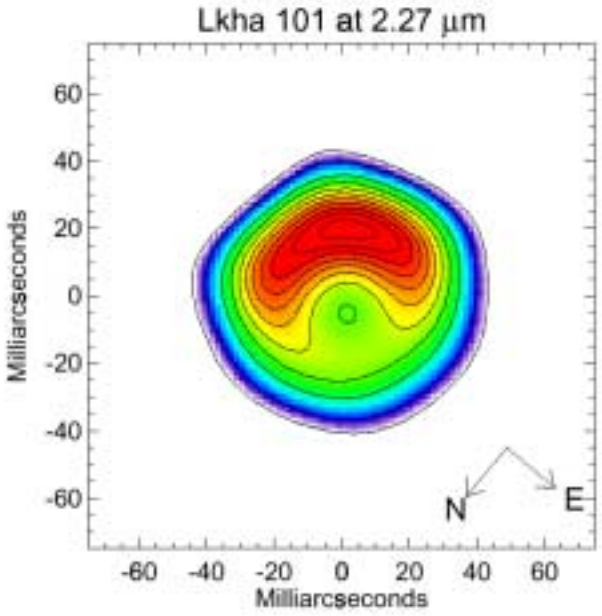
# Disks Around Herbig Ae/Be Stars



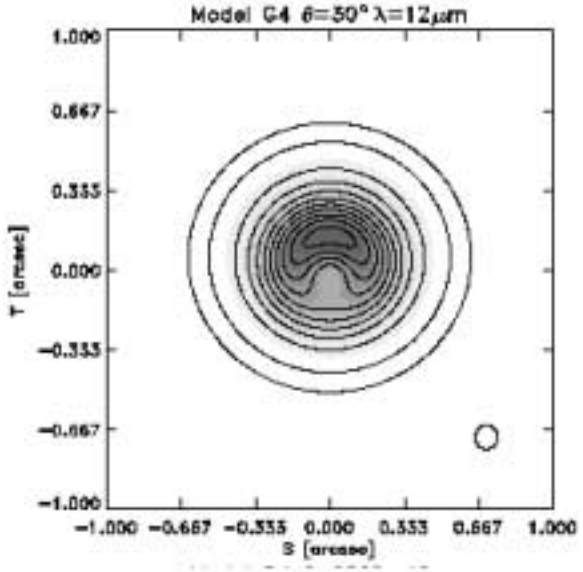

Tuthill, Monnier & Danchi 2001

Danchi, Tuthill & Monnier 2001

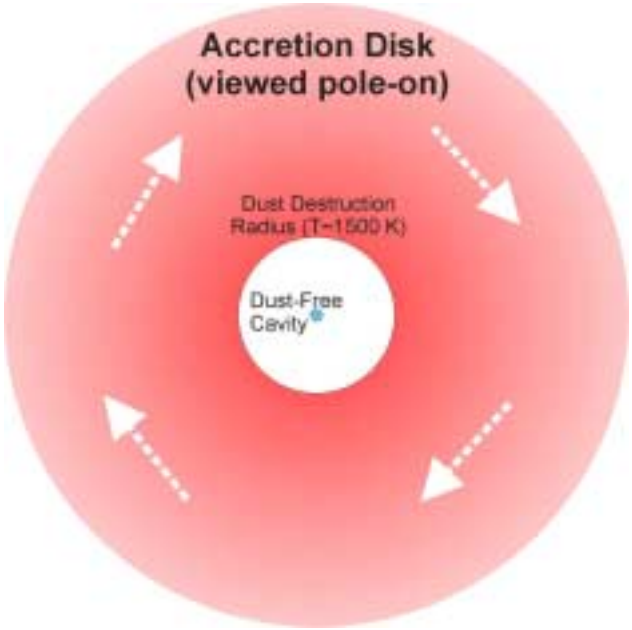
# Thermal Emission From Disk With Central Hole



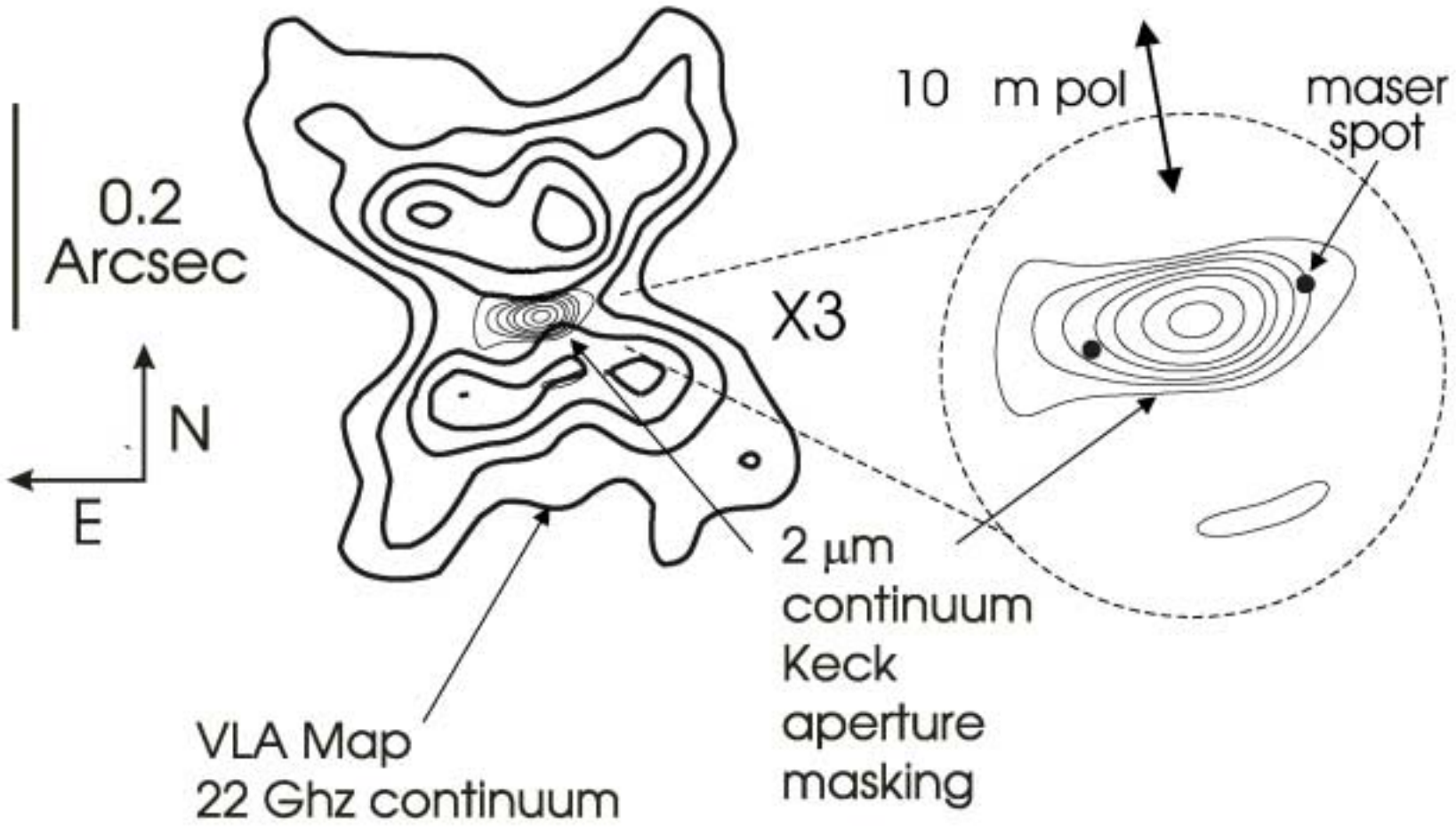

Tuthill, Monnier & Danchi 2001




Kessel et al. 1998



# MWC 349A






Danchi, Tuthill & Monnier 2001

# Segment Phasing Problems